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THE VALUE OF SCABBY POTATOES

By B. F. LUTMAN

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Scabby tubers kept under conditions of laboratory storage in dry air lost 38 percent in weight from fall to spring whereas clean tubers lost but 30 percent.

Scabby tubers kept under conditions of good cool cellar storage in shallow flats lost 25 percent in weight from fall to spring against 17½ percent loss from clean seed, and in bushel boxes 21 percent as against 15½ percent.

Neither clean nor scabby tubers lose any material amount of carbon dioxid through respiration. The loss in weight is practically all water. Stored potatoes whether clean or scabby, tuber for tuber but not weight for weight, contain as much food in the spring as in the fall, so be it they have not begun to sprout.

Ordinary paring losses on clean and scabby potatoes may be expected to approximate 18 and 33 percents respectively. On this basis, at the rate of a dollar a bushel for clean tubers, scabby tubers would be worth 82 cents, if one looks at actual nutrition values and shuts one's eyes to the fact that they are relatively unsalable and can not be baked to advantage. Their spring values would be still further decreased by increased water losses in storage, 82 cents becoming 76 cents.

Since scabby tubers if used for seed must be disinfected, their value, with clean seed at a dollar a bushel, would approximate 90 cents if the clean seed is not disinfected, 94 cents if it is disinfected.

BULLETIN 297: THE VALUE OF SCABBY POTATOES

By B. F. Lutman

Many potato growers are troubled each fall by finding more or less scabby potatoes in their fields. These appear in locations, often in definite areas in a field, where conditions favor the propagation and pathogenicity of the scab-inducing organisms. The worst of such areas can be readily avoided but many scabby tubers are found at harvest time around their margins. A natural prejudice exists on the part of buyers against these unsightly tubers. Their disposal is difficult since potatoes, especially in the open market, sell on the basis of appearance as much as because of their real food values. The present study was undertaken to determine the intrinsic value of such scabby tubers. Of course their market or sales value is quite another thing than is their intrinsic, their real, value. If this real value can be ascertained, then the buyer of such damaged stock would know just what he was getting for his money and the seller would be able to set a fair price upon it.

In a previous paper Lutman and Cunningham (1914) called attention to certain properties of scabby potatoes, saying: "It is the popular notion that the injury and loss falls only on the grower and is confined to the depreciation in value due to an unsightly appearance which lowers sales prices. But the consumer also suffers. He may buy at a lower gross price, but on the other hand he experiences a considerable loss of food material otherwise available, due to the deep paring needed to remove the scabs when preparing the potato for the table. Moreover some buyers object seriously to the peculiar earthy odor and taste which is characteristic of scabbed but is foreign to unscabbed potatoes. This quality, however, is not disagreeable to all people; indeed, many prefer scabbed potatoes because of this very odor and taste and because of their frequently increased mealy texture. This last quality is decidedly enhanced by severe scabbing. Neither taste nor mealiness are objectionable to the writers and they have known many people who were exceptionally fond of scabby potatoes."

These statements refer largely to the use of scabby tubers for table use. They bear no relation to keeping qualities or to their use as seed. Since the scab lesions open into the storage tissue of the tuber, opportunity may be offered for increased water loss and respiration. The normal procedure of these two physiological processes is

dependent upon the impermeability of the outer corky layer of the tubers. Whenever the scab spots destroy its continuity increased water losses ensue and respiration is affected. Hence a brief statement as to the nature of the "potato skin" and of the scab lesions which often appear thereon seems called for, although in part it is a repetition of matter occurring in the bulletin above cited.

The potato tuber is covered by a brown corky layer, varying more or less in different species (Lutman, 1919) but composed of a number of rows of cells with cork impregnated walls. Scattered over this brown surface occur some slightly raised portions of a different and looser texture. These lenticels or breathing pores permit the passage of gases between its cells. They become especially prominent in tubers grown on heavy, wet soil.

The scabby lesions are produced by the intrusion of and stimulation induced by certain higher bacteria. These organisms grow in the intercellular spaces of the lenticular tissue. Their very presence or, perhaps more likely, the toxins created by their life processes lead to the formation of an unusually large amount of cork tissue and of parenchyma. The scab spot, therefore, becomes swollen and is considerably raised above the surface of the cork. A general skin infection may occur but the real damage is confined almost entirely to the lenticels. The tuber heals under the scab spot but this healing process is not as a rule entirely completed as long as the tuber remains in the soil. Once removed, however, a continuous and impervious layer of cork soon forms under each lesion, shutting off the abnormal tissue from the starch-containing portions of the tuber and thus restricting the loss of water. The growth of such a layer is unnecessary as long as the tuber remains in the soil, for the damp soil air does not stimulate such a complete growth. Hence it is that the scab lesions in tubers which have been dug and stored for some time differ somewhat in structure from those observed before harvest.

How rapidly after harvest does this corky layer form? Is it as complete and as impervious as is the normal skin with its lenticels? Data gathered at sundry times during the past seven years on water and carbon dioxid losses from scabby and from clean tubers enable the writer to answer these queries. These data have been collected in large part by the writer and in part by a (then) undergraduate student, Mr. Oliver Orton, during the past year by the assistant plant pathologist, Miss Winona E. Stone, to both of whom the writer is indebted for assistance.

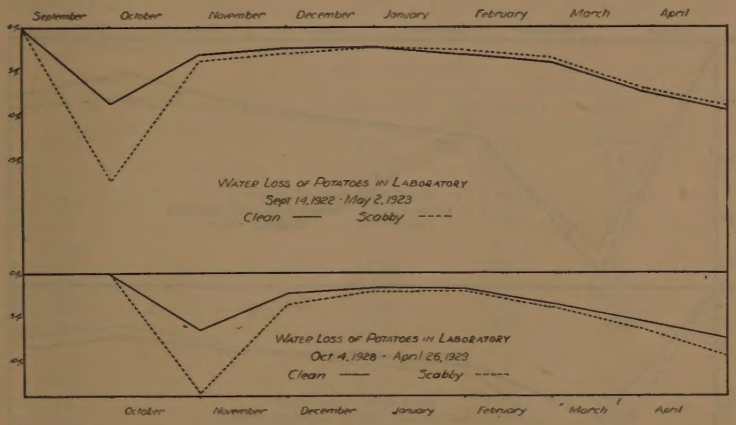
WATER LOSSES

Scab lesions would seem to induce increased water losses, especially during the early part of the storage, as the curves indicate. The general method used in obtaining these data was to store clean and scabby tubers as promptly as possible after harvest—usually within a few days—in boxes either in an excellent, underground, unheated cellar or, more rarely, in the laboratory. Weights were made at the outset and at frequent intervals thereafter, usually every few days for a month and thereafter once a week. The losses were figured in terms of percentage of the original weight and recorded as a curve.

LABORATORY STORAGE

(1922-23; 1928-29)

The laboratory air was very dry and water losses very rapid for a few days after storage began (curve 1), but this rate of loss slowed down during the latter part of the season. Five thousand eight hundred and twenty grams of clean and 5,847 grams of scabby Green Mountain tubers put into storage September 14, 1922, were held there until May 2, 1923. Beginning about February 1 some sprouting



CURVES I AND II

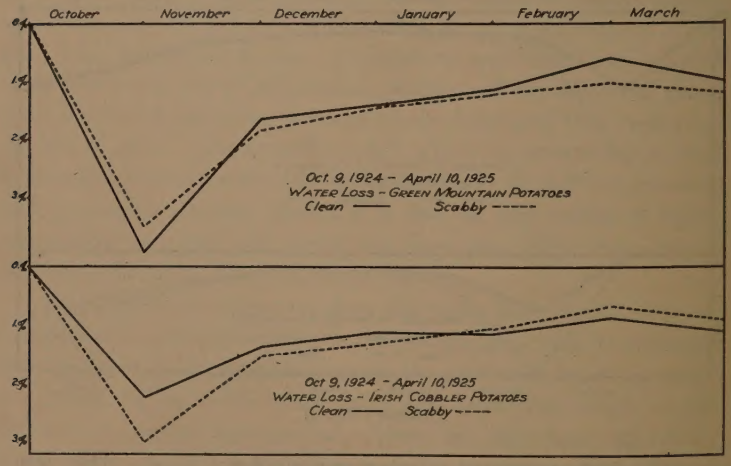
occurred which augmented to tuber transpirational losses. The clean tubers weighed 3,816 and the scabby ones 3,496 grams on May 1. The losses were respectively 34.4 and 40.2 percents and are plotted in curve 1.

Two thousand seven hundred and twenty-eight grams of clean and 3,465 grams of scabby tubers were similarly put into storage on October 4, 1928, remaining until April 26, 1929. The final weights were, respectively, 2,025 and 2,202 grams, the losses 25.8 and 36.4 percents. The losses from month to month were plotted in curve II.

Curves I and II follow the general shape already described. Weights drop sharply during the first month in the 1922-23 curve and during the first two months in the 1928-29 curve. The scabby tubers lost more than did the clean ones, particularly in 1922-23, probably because they were stored fresh from the soil whereas the 1928-29 lots were dug about a week before they entered storage. After the lapse of the one or the two months, as the case might be, all curves tended to become roughly parallel. The tubers apparently adapted themselves to the changed environment and the scab lesions had healed.

CELLAR STORAGE

The dry and warm laboratory air presented unusual conditions. Much more natural surroundings were afforded in cellar storage. No temperature records were kept, but the variations were between 35 and 50 degrees with an average of about 40° F. The air was dry, especially in 1928-29.



CURVES III AND IV

1924-1925. Six thousand seven hundred and sixty-four grams of clean and 6,688 grams of scabby Green Mountain tubers were stored

from October 9 to April 10. Weights were recorded weekly. The weight losses are shown in curve III. Eight thousand six hundred and ninety-five grams of clean and 7,599 grams of scabby Irish Cobblers were stored at the same time and weighed weekly, with results shown in curve IV. The Green Mountain clean tubers lost more during the first two weeks than did the scabby ones, but thereafter the loss from the scabby ones was greater for a time. The Irish Cobbler scabby tubers lost more than the clean ones during the first six weeks but thereafter the losses from the two lots practically were parallel. The total percentage losses were:

	Clean %	Scabby %
Green Mountain	8.5	10.7
Irish Cobbler	11.2	12.1

1928-29. The tubers (Green Mountain) were placed one deep in green-house flats with a surface area of 264 square inches, eight boxes being used, four for clean and four for scabby tubers. Two bushel boxes—surface area 144 square inches—were filled with clean and two with scabby potatoes at the same time. The trial lasted from October 5 to April 26. The data are given in the following table and in curve V:

TABLE 1.—LOSS OF CLEAN AND SCABBY POTATOES IN CELLAR STORAGE

A.—IN SHALLOW FLATS

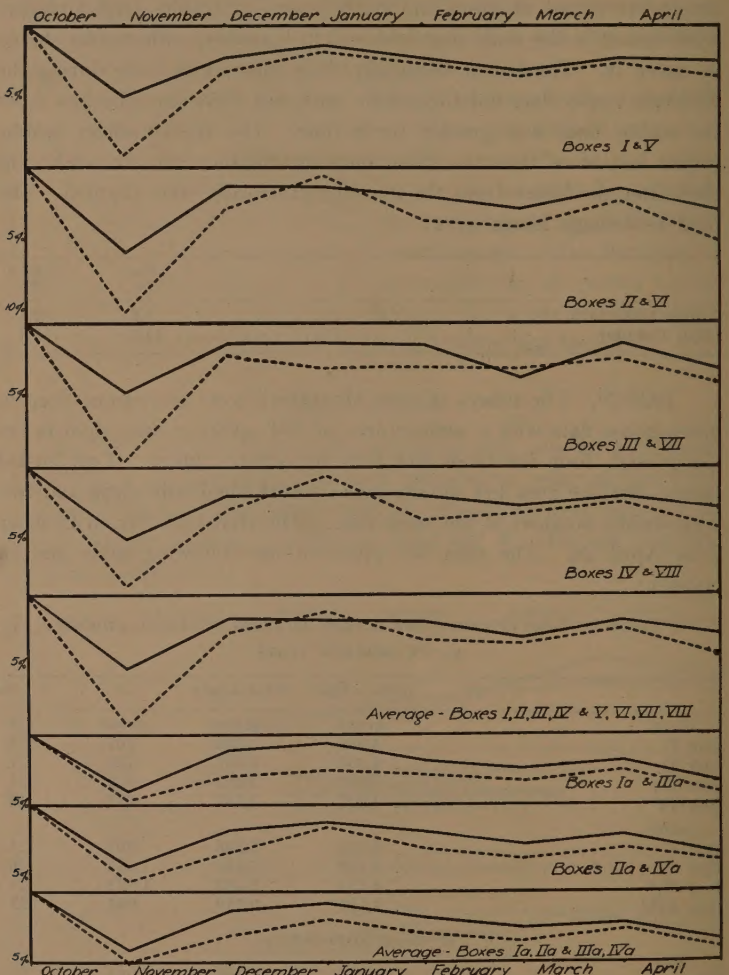
	Initial weight	Final weight	Loss	Loss
Clean	grams	grams	grams	%
Box I	3,939	3,232	707	18
Box II	4,280	3,542	738	17
Box III	4,052	3,373	679	17
Box IV	4,477	3,686	791	18
Scabby				
Box V	3,855	2,948	907	24
Box VI	4,252	3,150	1,102	26
Box VII	4,224	3,203	1,021	24
Box VIII	4,111	3,150	961	23

B.—IN BUSHEL BOXES

Clean				
Box Ia	27,216	23,262	3,954	15
Box IIa	27,216	22,850	4,366	16
Scabby				
Box IIIa	27,188	21,432	5,756	21
Box IVa	27,216	21,432	5,784	21

The statements made above for 1924-25 hold true for 1925-26. The large losses at the outset were gradually checked after about two

months. The losses from both lots then became roughly parallel to each other, with the scabby tubers evidencing slightly larger losses.



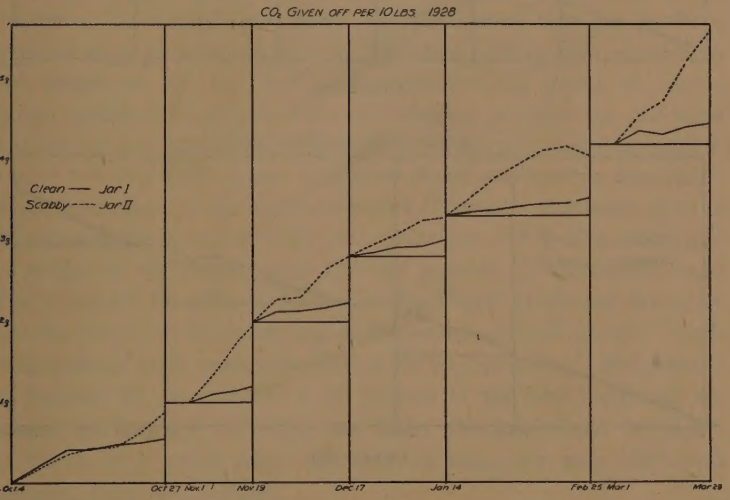
WATER LOSS OF POTATOES IN STORAGE IN FLATS AND BUSHEL BOXES

CURVE V

CARBON DIOXID LOSSES

The scabby lesions are really enlarged lenticels. Their enlargement affords opportunity for increased interchange of gases and pre-

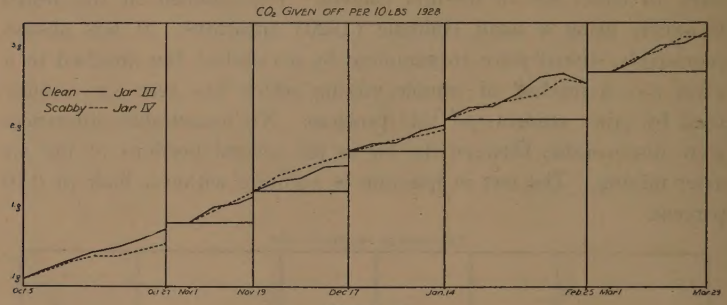
sumedly augments the loss of carbon dioxid from the interior of the tubers. Earlier studies heretofore reported upon by the author (1926) indicated that scabby tubers respired more freely, that is to say, gave off more carbon dioxid than did clean ones, weight for weight. However, the divergency was so slight that repetition was indicated. Several lots of from four to six medium-sized tubers were placed under vaseline-sealed bell-jars. Approximately even-sized tubers were chosen, whether clean or scabby, and the bell-jars in each case were of identical sizes, of either six- or ten-liter content. The confined air was tested bi-weekly using a small Haldane (1920) apparatus. It was always thoroughly stirred prior to sampling by a celluloid fan attached to a glass rod, a method of sample mixing which has been successfully used by other students of this problem. No measurable differences were discoverable between the air in the several portions of the jar after mixing. The test in question is accurate within a limit of 0.10 percent.



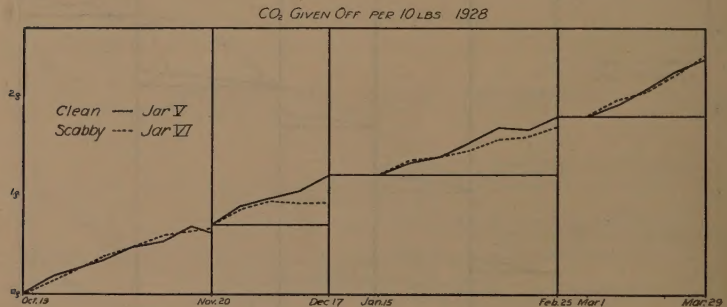
CURVE VI

After the several lots had been kept in confinement for varying lengths of time they were removed and others selected from storage were substituted. Because of the somewhat abnormal conditions to which these imprisoned tubers were subjected, such exchange seemed advisable. All the bell-jars and all tubers in storage were kept under uniform cellar conditions. The cellar temperatures were low, varying from 12° C. in the early fall to 2° C. in the midwinter.

The Haldane apparatus reads directly the percentage of carbon dioxid in parts per ten thousand. The amount present in each jar was computed from this percentage, the exact space—approximating a liter—occupied by the tubers being allowed for in each instance. The computed weight of carbon dioxid was then calculated on the basis of 10 pounds of tubers. These data have been plotted as curves V-VIII, the latter representing the composite results. As a rule the results in individual cases showed that the scabby seed lost more than did the



CURVE VII



CURVE VIII

TABLE 2.—SUMMARY OF RESPIRATION (CO_2) FOR 10 POUNDS (APPROXIMATELY 5 KILOS) THREE JARS EACH OF CLEAN AND OF SCABBY POTATOES

	Clean		Scabby	
	Per day	Total for period	Per day	Total for period
Oct. 4-29	0.028	0.700	0.036	0.925
Nov. 1-19	0.017	0.306	0.032	0.576
Nov. 19-Dec. 17	0.012	0.340	0.018	0.500
Dec. 17-Jan. 14	0.009	0.265	0.013	0.380
Jan. 15-Feb. 25	0.010	0.420	0.014	0.556
Mar. 8-29	0.016	0.440	0.029	0.820
Total for storage period		2.471 g.		3.757 g.

clean, but at times the reverse proved true. No explanation can now be offered for these divergencies. However, on the average, taking all records together and for the entire time that the trial was under way—approximately six months—the scabby potatoes respired more freely than did the clean tubers.

The above data would seem to indicate that potato tubers in storage, whether clean or scabby, lose only a negligible weight by respiration and the formation of carbon dioxid. Much the same conclusions were reached by Appleman, Kimbrough and Smith (1928) with respect to clean tubers. The loss from tubers in storage is largely a water loss. This being the case, stored potatoes in the spring, so be it they have not begun to sprout to any extent, contain the same food value they did in the fall when freshly dug, tuber for tuber but not pound for pound.

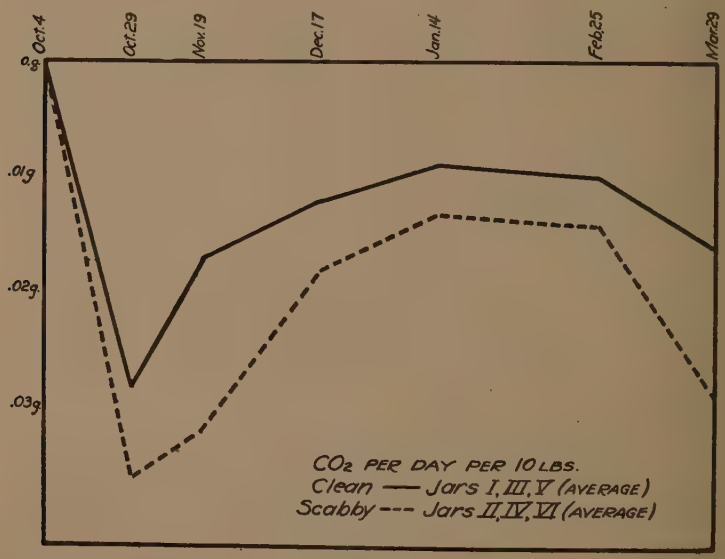
These results are less pronounced than those obtained at any time by Bennet and Bartholomew (1924), by Kimbrough (1925) or by Appleman, Kimbrough and Smith (1928); indeed they are hardly a tenth as great as were obtained by the latter authors who say that "a kilo sample at 20° C. (71.6° F.) respired 3.192 grams of carbon dioxid during the first nine days after digging but this does not mean that the potatoes actually lost this much in weight on account of respiration. * * * The 3.192 grams of carbon dioxid produced in respiration would correspond to the destruction of 2.176 grams of glucose and the liberation in the tissues of 1.305 grams of water. * * * The actual loss in weight of the sample of potatoes on account of respiration would then represent the difference between the weight of glucose destroyed and the weight of the water left in the tissues, or 0.87 gram." These weight losses from respiration during the storage period, November 2 to January 18, amounted to 0.162 percent of the total weight of the tubers; the losses in the trials now under discussion from October 4 to March 29, a period more than twice as long, were only about 0.02 percent of the total weight.

No thoroughly acceptable reason for these discrepancies can be advanced by the writer. The general shape of the curve obtained in either case was very similar. However, the results obtained by the authors cited were secured by a procedure quite unlike that employed by the writer. They withdrew the air in the bell-jars by suction through alkaline solutions and titrated them for their carbon dioxid contents. Their results as have been pointed out are uniformly much higher than those reported here. However the suggestion may be made

that in removal by suction not only was the gas already located outside the tubers displaced, but that that located in the intercellular spaces may have found its way through the lenticels into the circumambient atmosphere of the bell-jar and thence out into the absorbing alkaline solution. Intercellular air contains a very high percentage of carbon dioxid. Two samples examined by Magness (1920) showed 18.6 and 34.4 percents. If even a modicum of this enclosed (intercellular) carbon dioxid should find its way out through the lenticels into the bell-jar air during the displacement operations, the apparent total amount present in that air might be considerably increased. Unfortunately this author did not determine the total amount of gases held in the intercellular spaces.

Are Scabby Potatoes Fit to Eat?

The flavor of the tubers is somewhat altered by the scab lesions. Some say that they are sweeter, but to the writer the flavor seems better described as "earthy" or as a pungent potato taste. The scab or-



CURVE IX

ganism produces various organic compounds which, being absorbed by the tuber cellular structure, are responsible for these secondary flavors. Some persons dislike the taste, others prefer it, while the average

observer would not notice enough difference to warrant depreciation in price on that score.

In the removal in paring of all traces of scab spots, much more of the storage material must be cut off than when healthy tubers are handled. Furthermore, as the storage season advances, the scab lesions sink lower into the storage tissue and deeper parings must be made. A series of paring of clean and scabby Green Mountain tubers was made at various times during the winter of 1928 to determine the relative percentages removed. Some were made as thin as possible, so be it all traces of the scab spots and of the eyes were removed, while in other cases the paring was done rapidly and losses were necessarily greater. The results of these trials are summarized in the following table:

TABLE 3.—LOSS IN PARING CLEAN AND SCABBY POTATOES

	Before paring grams	After paring grams	Losses %
Jan. 23, thin paring			
Clean	2,325	2,042	12.2
Scabby	2,325	1,782	23.4
Feb. 6, average paring			
Clean	1,400	1,153	17.7
Scabby	1,400	922	34.1
Feb. 15, average paring			
Clean	1,582	1,257	20.5
Scabby	1,567	980	37.5
Feb. 27, rather thick paring			
Clean	2,960	2,377	19.7
Scabby	3,362	2,146	36.2
Mar. 25, thick paring			
Clean	1,703	1,327	22
Scabby	1,796	1,112	38
Average five parings			
Clean	9,970	8,156	18.2
Scabby	10,450	6,942	33.5

These results indicate that about 15 percent more of the structure must be removed from the scabby tubers than from the clean tubers in order to free them from all traces of the scab spots. This additional loss must be compensated for by a corresponding lower price for scabby potatoes. On this basis, if a bushel of clean potatoes is worth a dollar a bushel of scabby ones ought to bring about 82 cents (60 pounds per bushel, 82 percent clean potatoes pared = 49.2 pounds, 66½ percent scabby potatoes pared = 39.9 pounds, 49:40::100:82). This suggested price differential takes no cognizance of the undesirable appearance of scabby potatoes, of the fact that on this account they are relatively unsalable, and of the fact that they are not suitable for baking purposes. It simply sets forth the real difference in the nutritive values expressed in terms of dollars and cents.

SCABBY POTATOES AND STORAGE DISEASES

The scabby potatoes seem to be no more subject to rot in storage than are clean ones. The scab lesions offer no means of entrance for further invasion of parasitic fungi.

SCABBY POTATOES AS SEED STOCK

The heaviest loss falls upon the grower of seed potatoes, to whom the scabby portion of his crop is often almost an entire loss since as a rule they can only be fed to hogs. If such tubers were sold at a discount to some growers who were willing to take the additional trouble thoroughly to disinfect them before planting, the extent of the financial loss would be lessened. Scabby tubers, as has been previously noted (Lutman and Cunningham, 1914) are just as good for seeding purposes as are the clean tubers, provided the scab lesions do not so cover the eyes as to inhibit germination. Should a grower attempt to use such seed, the safest procedure would be to reject the badly infected tubers covered entirely with scab and to disinfect the residue of the stock. The real value of this residue would depend, therefore, largely on the original cost of the seed and the cost of disinfection.

The cost of disinfection. Gilbert (1917) gives figures on disinfection costs which agree fairly well with those secured in the writer's experience. Two men well equipped can disinfect 250 bushels a day with formaldehyde or corrosive sublimate.

12½ pints of formaldehyde, at $2.50 a gallon, in 12 barrels of 30 gallons of water, each barrel being used 10 times	$3.75
Labor at $3 a day	6.00
Total cost	$9.75

Cost per bushel for this treatment approximately four cents.

4 ounces corrosive sublimate in 30 gallons of water, using each 30 gallons three times, corrosive sublimate at $3 a pound	$30.75
Labor at $3 a day	6.00
Total cost	$36.75

Cost per bushel for this treatment, approximately 14 cents.

Stuart (1927) gives no detailed estimate of the cost of disinfection, this factor probably being included in the expense of seed.

Gilbert's method outlined above is wasteful of the expensive corrosive sublimate. Some growers use the solution, as originally made up, three times and then add an ounce of corrosive sublimate to compensate for that which has been removed by the tubers in the disinfection process. Corrosive sublimate, unlike formaldehyde, is removed

with each disinfection and the solution gradually becomes weaker and is maintained at its pristine strength only at the cost of these periodical additions. Using this replacement method the cost would be as follows:

5 pounds of corrosive sublimate at $3 per pound	$15.00
Labor at $3 per day	6.00
	$21.00

Cost per bushel for this treatment approximately eight cents.

Some of the recently discovered mercuric compounds (such as "Uspulin," "Semesan," and "Germisan") cost about as much to use as corrosive sublimate, with which they successfully compete as seed disinfectants. One grower has informed the writer that he had disinfected 360 bushels of seed potatoes with 25 pounds of Semesan Bel. At the rate at which he paid for the chemical, it was much cheaper than the more expensive corrosive sublimate method and cost just about the same as the replacement procedure above outlined.

The cost of disinfection would add to the price of scabby potatoes to be used for seed purposes at the most 15 cents per bushel if disinfection is done by the most expensive corrosive sublimate, eight cents by the more economical corrosive sublimate replacement method or by the use of one of the organic mercury substitutes and only about four cents if formaldehyde is used. The labor cost of the formaldehyde treatment can be even further reduced if the chemical is applied hot and for a shorter time, only a few minutes immersion in the hot liquid being required.

An estimate may be made of the prospective spring values of clean and scabby potatoes bought in the fall.

1. *For culinary purposes.* In spite of their unsightly appearance scabby potatoes at any time during the winter or spring have very nearly the same food value as do clean ones. If a bushel of clean tubers can be bought in the fall for a dollar, the prospective value of a bushel of scabby ones bought at the same time for eating in the spring would only be about 76 cents. The scabby potatoes lose from transpiration and respiration about 6½ percent more than do clean ones and when pared about 15 percent more must be removed to free them from the deepest scab lesions. The calculation then becomes as follows:

Fall value of clean potatoes per bushel (60 lbs.) $1.
18 percent loss from paring clean potatoes. 82 x 60 = 49.2 lbs. ready to boil.
33⅓ percent loss from paring scabby potatoes.
6½ percent increased transpiration and losses due to cutting.
93.5 x 66.5 = 62.2. 62.2 x 60 = 37.3 lbs. ready to boil.
49.2 : 37.3 :: 100 : 76. Fall value scabby potatoes, 76 cents.

2. *For seed purposes.* The worst infected specimens should be entirely rejected for seed purposes since the eyes may be sometimes covered. The others may be disinfected with formaldehyde or corrosive sublimate and planted.

The value of clean and scabby tubers bought in the fall may be estimated as follows:

If a bushel of clean tubers has a value of a dollar at digging time, a similar bushel of scabby ones would be worth only 89½ cents if they could be disinfected with formaldehyde, or 90 cents if disinfected with corrosive sublimate. The scabby potatoes during the storage season will lose about 6½ percent more water and carbon dioxid than will the clean ones. The disinfection with formaldehyde will cost approximately four cents a bushel, with corrosive sublimate about 13½ cents.

Fall value of a bushel of clean tubers	$1.00
Deduct for increased loss of scabby tubers by transpiration and respiration, 6½ percent	0.065
Prospective value of scabby ones in fall	$0.935
Disinfection with formaldehyde, four cents per bushel	0.04
	$0.895
or	
	$0.935
Disinfection with corrosive sublimate at eight cents per bushel	0.08
	$0.855

Many growers disinfect all their seed whether the presence of infection is or not apparent. The cost of disinfecting a bushel of clean tubers is just as much as of a bushel of scabby ones, so if the disinfection differences be omitted from the scabby lots the bushel of scabby tubers is worth 93½ cents.

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